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INSTRUCTIONS TO LIGHT KEEPERS ON PRIMARY TRIANGULATION

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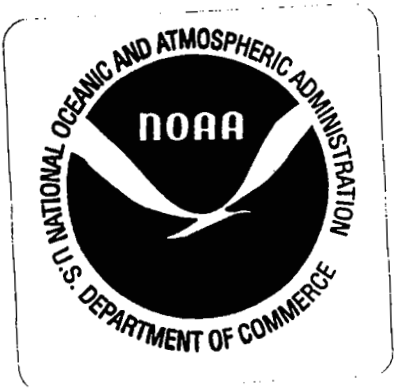
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INSTRUCTIONS TO LIGHT KEEPERS ON PRIMARY TRIANGULATION.

INTRODUCTION.

In order that the light keeper may understand something of the general nature of the work of the party and be able to answer the questions of interested persons, a brief description of triangulation as carried on by the United States Coast and Geodetic Survey is here inserted.

Triangulation is an accurate determination of the distance and direction between the various permanently marked points of a survey scheme, laid out on the surface of the earth to cover a certain area, without the actual measurement of the various lines by chain or tape. Triangulation is a skeleton survey and serves to coordinate and adjust the local surveys within its area and to connect them in their proper relation with the remainder of the surveyed portions of the country. It is done by measuring with great accuracy the distance between two survey stations, and also measuring at each station the angles between the adjacent stations of the survey scheme when by trigonometry the distances be-

tween all the stations may be computed. If the latitude and longitude of one station are known and the direction to other stations either known or measured, the latitude and longitude of each station may be computed in turn.

The direction of the line joining the first two stations, or the azimuth of the line, as it is commonly called, is found by observations on Polaris, the North Star. Similar observations to check the directions are made at various points as the work progresses.

In measuring the angles between stations, some of which may be as much as 100 or 150 miles from the observer, it is necessary to use lights at the various stations, each managed by a light keeper whose business it is to keep the light directed toward the observer's station. These lights are either acetylene or electric lamps or heliotropes, the latter being an arrangement of mirrors for reflecting the rays of the sun in any desired direction. The lights are also used for signaling purposes, whereby, with the Continental Morse Code, instructions and other necessary information about the work are sent between the observer and the light keepers.

To make it possible to see from one station to another it is often necessary to build towers higher than the surrounding trees or high enough to enable the observer to see over some distant intervening obstruction.

In any locality which has been covered by triangulation many permanent marks other than those specially prepared are located for the use of the engineer and surveyor, such as church spires, water tanks, belfries on

schoolhouses and courthouses, large, prominent trees, and other objects. These are located by observations from two or more stations of the main scheme.

Special care is given to the marking of the stations to secure them against destruction. The surface mark is usually a small brass disk, cemented into a hole in a rock ledge or set in the top of a concrete post, while reference marks are set at various distances to assist in finding the station. A description of each station, with its latitude and longitude and its distance and direction from various other stations, is published by the Coast and Geodetic Survey as soon as practicable after the completion of the field work, and will be gladly furnished to any person desiring it.

Triangulation, besides connecting the various large public surveys throughout the country, is of direct benefit to many people in the territory through which it is extended by its connections with the local land surveys and the city surveys. The stone or concrete posts set in the course of the work bear the same relation to triangulation as the blazed trees and corner posts bear to the ordinary land survey. Before any future work can be begun it is first necessary to recover one or more marks from which to start. To prevent the destruction of these marks, the assistance of the people living in the vicinity of a station is earnestly desired.

A brief descriptive outline of the several classes of work done by the United States Coast and Geodetic Survey will be found near the end of this pamphlet.

INSTRUCTIONS.

CONTINENTAL MORSE ALPHABET.

A .—	J .———	S ...
B —...	K —.—	T —
C —.—.	L .—..	U ..—
D —..	M ——	V ...—
E .	N —.	W .——
F ..—.	O ———	X —..—
G ——.	P .——.	Y —.——
H	Q ——.—	Z ——..
I ..	R .—.	

The notations for numerals will be dispensed with and the numbers spelled out when required.

The Continental Morse differs from the American Morse in that there are no "spaces" between the elements of the letters.

SIGNALING.

Dots should be short, just long enough to permit the lights to be seen clearly.

Light should shine for dash about two seconds. Duration of darkness between elements of letters, one second.

Duration of darkness between letters, three seconds; duration of darkness between words, five seconds. If the lights are dim these periods may be somewhat longer. It is not important that these periods should be absolutely observed, but the relative proportion should be maintained.

The alphabet must be committed to memory; also, what is more difficult, *all letters must be easily recognized by seeing their elements.* Perfection in this matter will eliminate much trouble, as most of the difficulty is due to the receiver not being able to recognize a letter before the next one has begun.

Maintain a uniform speed in sending, for varying speeds make the receiving of the message difficult.

Be careful that *all light* is cut off between elements of letters.

Do not use the hand for covering up the light when signaling.

Cut the light off and on by quick chopping movements.

A light keeper calls the observer by sending his own letter until answered.

The observer calls a light keeper by showing a steady light to him, whether with helio or lamp. A steady light from the observer's station means either that your light is not satisfactory or that he wishes to send you a message. First inspect your light and then answer the call.

Answer a call by a series of slow dots (not more than seven), then watch for signal, by aid of the binoculars when necessary.

If the reason for the call from the observer was that your light was not satisfactory, the observer will O. K. by dots as soon as the trouble is corrected, and will then turn off his light.

When two light keepers are so located that each is able to see the light intended for the other, both must answer when called, then the letter of the light desired will be sent by the observer.

If the lights are faint, before beginning a message give the one to whom it is sent time to steady his binoculars on the light before cutting it off. Darken the light for about 10 seconds before beginning message. The practice of sending dots before darkening the light is often confusing on long lines, and should not be practiced unless authorized by the chief of party. Do not cut off your light while receiving a message.

All messages are to be repeated by the receiver, except in case of messages from light keeper to observer. Here the observer will answer by sending slow dots. NEVER REPEAT A WORD UNLESS YOU ARE SURE IT IS RIGHT. This is a decided annoyance to the observer and a source of a great deal of trouble. If an observer knows that a message has not been received, he is at least in a position to know what to do to remedy matters. Should you fail to get the first part of a message, break in with *R*. If first part of message has been received, repeat words you are sure of, then send *R* for remainder. Where lights are faint or light keepers not adept at receiving messages, it is better to send one word at a time and have that repeated before proceeding to the next.

CODE SIGNALS.

A series of quick dots means "I have made a mistake, and will begin again."

AA means "Stand by, will need you soon" (10 or 20 minutes).

A means "Wait a while."

"Get," followed by the name of a station, means: "Get person at that station by calling him, and tell him where observer is."

N, "Your light is too faint."

R, "Repeat message; I could not get it."

A series of slow dots, "I understand your message."

M, "Moderate your light; it is too strong."

Z is the distinctive letter of the observer; it is never sent by a light keeper, not even repeated; only O. K'd by slow dots. Therefore, a light keeper seeing *Z* knows that observer is at that place and shows to him.

Light keepers in relaying messages refer to observer as *O*.

SIGNALS TO BE USED BY THE OBSERVER WHEN COMMUNICATING WITH A LIGHT KEEPER.

ST, followed by name of station and date, means: "Stop showing light to this station; show to the station indicated on date named and look for observer's call."

ST, with no name of station, means: "Stop showing light to this station, and show light to the station to

which observer goes, which is indicated on the written schedule of observer's moves, a copy of which has been furnished to you." If no date is given, show to new station at next observing period.

THD, "Have finished on you for this afternoon (or night); show to this station again at next observing period."

DG, followed by name of station and date, means: "Done where you are; go to the station named, show light, and look for observer's call on date given."

DG, with no name, means: "Done where you are; go to the next station mentioned in your written schedule of moves and show light to the observer at his old or new station, according to the schedule." If no date is given, begin showing light at first observing period after station is reached.

DGK means that the move indicated by the *DG* will be made by truck, which will call at the nearest accessible point for you and take you to your next station.

DGRK, followed by the name of a railroad station which is near your next station, means: "Done with you where you are; go by train to the railroad station mentioned, where the truck will meet you and take you the remainder of your way to your station."

DGKR, followed by the name of a railroad station near your present station, means: "Done with you where you are; go by truck to the railway station named and from there go the remainder of the distance by train and private conveyance."

If the observer sends an *A* after 10 p. m. it means that the light keeper is to stay on the tower and keep a sharp lookout until called again. Should this be followed by an *L* it signifies that the light keeper is to recharge the lamp and leave the station for the night.

ST or *DG*, followed by an *L*, means: "Leave your lamp burning to-night, but to-morrow follow instructions given by the *ST* or the *DG*.

FINI, "Have finished on you; obey written instructions."

"Money," "Mail," etc., followed by name of place, means: "The article is at the place named."

"No" means you have not repeated message correctly and that correct message will again be sent you.

SIGNALS TO BE USED BY LIGHT KEEPERS TO OBSERVER.

"Money," "Carbide," etc., means: "I am in need of same." Other necessary messages will be spelled out in full.

Keep a sharp lookout for signals at all times; if lights are faint, look for signal every few minutes with binoculars.

N's may be sent any time if your light is poor.

SIGNALS TO BE USED BY A LIGHT KEEPER TO ANOTHER LIGHT KEEPER.

O, followed by the name of a station, means: "Observer is at that station; show to him at once."

GENERAL CONSIDERATIONS.

Before starting out alone be sure that some one of the party has taught you how to use the signal lamp and how to test and adjust a heliotrope and to put on the cut off rings on the heliotrope and lamp.

Test your heliotrope and lamp so that the light goes to the observer, for the line through the sights may point to the observer, but the light may not be centered on him.

A correct vertical pointing is as necessary as an accurate horizontal sighting. Test the carbide lamps for vertical pointing each time a new burner is put in.

Every day, if necessary, see that your lamp drops water fast enough to give a strong light.

Keep your heliotrope and lamp in good condition. When the air is clear, a poor light possibly may be seen, but if it is hazy only a clean lamp and reflector will give good results. The carbide chamber should be cleaned as soon as possible after getting through using the lamp, as the metal is corroded if carbide is allowed to stand in it.

At every opportunity get the correct standard time and keep your watch within a few minutes of it.

The first thing to do when reaching a station is to try to locate all of the stations to which you will show. By doing this at the first opportunity, and not waiting for the exact moment that you expect your light to be used on a line, you will avoid causing delays to the observing party.

Where smoke, clouds, and fog are encountered, the value of getting your pointings on the clear days is evident. After finding a station you should hold the direction to it by lines marked on the stand or by any other means practicable. When you are on a wooded peak and there has been a delay in seeing the observer's light, watch carefully for him, for the light might be obstructed close to your station and you might be able to see the call from the top of a tree or from some other point on the mountain. In other words, do not be absolutely sure that the line is open unless you have seen a light from the other station, and unless you are sure, keep trying to get the observer's call by watching very closely.

When the observer's light is once seen, set your telescope on it and fasten or mark it so that you will know you have the direction of the line, even if the weather should become cloudy or smoky. Then point your heliotrope, using thin wedges if necessary to get the proper elevation, and mark the place on the stand where each wedge belongs, and also mark the wedge to show how far it is to be pushed under the heliotrope; also mark along the side of the heliotrope box for the direction. Then you can replace your heliotrope exactly after it has been disturbed. The lamp may be set and pointed by the lines made for the heliotrope. When in trouble about the direction of the lines, always keep watching for calls from stations other than the observer's, for the observer may be sending a message to you through one of the other light keepers.

Your work on the tower begins at 2 p. m. From then until 4.30, unless instructed otherwise by the observer, you should show your heliotrope all the time if there is sun enough to make a shadow. If your heliotrope is pointed with care, a faint sun is just as good to show the observer as a bright sun on comparatively short lines; also, if you get only a faint sun every 10 minutes or so, which lasts for a short time, it may be used by the observer. It is not for you to decide whether you think it worth while, or whether the observer can use it or not. An effort will be made to send you *THD* as often as practicable.

At 11 p. m. begin sending slow dots (about 20 at a time) and remain on the lookout for signals for 15 minutes (until 11.15). If no signals are received, see that the light is burning well (recharging if desirable) and then you can leave the tower for the night.

Keep a lookout for the observer's call from his next station, as he may have moved without notifying you.

The lamps should be set up and lighted 20 minutes before sundown. This is important, and every effort should be made to be punctual in lighting lamp at this time. After recharging watch the lamp closely for 15 minutes.

Be careful to sight your lamp and heliotrope accurately; if in doubt, send your initial, then the observer will show you a light.

Be extremely careful not to have lanterns or other extra lights about the tower. They are often mistaken

for the signal lights by the observer. Frequently they can be seen at the foot of the tower at well as on the top.

When your line is 10 miles long, or less, watch for an *M*, meaning that your light is too strong and should be reduced by means of the concentric rings provided, or by paper rings cut out true.

Keep your tents, mess outfits, instruments, and other articles of equipment clean and in order.

Before the observer arrives the light keeper should find out the name and address of the owner of the land on which the station is located, being careful that the spelling of the name is correct. This information is for the description of the station to be published later.

It should be remembered that the towers are built with the least material required for safety; that the signal notices apply to light keepers as well as to other people, and therefore you should in no way weaken the scaffold by removing any of its parts.

An extra effort should be made to move between stations as rapidly as possible to prevent holding back the observing party longer than is necessary.

So much depends upon the efficiency and faithfulness of the light keeper that an indifferent one must be disposed of as soon as convenient.

In addition to the sketches showing the scheme of triangulation as located by the reconnoissance party, the light keepers will be given descriptions of the stations which will enable them to move from station to station. They will be given lists of the triangulation

stations in the order in which they will be occupied by the observer, and each light keeper will also be given a statement of his own moves and for each of his stations the line or lines over which he is to show a light. This information will be tabulated in the following form:

Schedule of moves for observer and light keepers.

Observer.	Light keeper "B."	Light keeper "D."	Light keeper "H."	Light keeper "K."	Light keeper "P."	Light keeper "U."	Light keeper, extra.
Haystack..	Rawhide.	Hobbs...	Willow.	Coleman .	Notch.	Chugwater	.....
Coleman...	Haystack	...do....	...do...	...do....	...do..	...do.....	.....
Notch.....	...do....	Whitaker	Ragged	...do....	...do..	...do.....	.....
Chugwater.	...do....	...do....	...do...	...do....	...do..	...do.....	.....
Whitaker..	Wadhill..	...do....	...do...	Greentop.	...do..	...do.....	.....
Ragged....	...do....	...do....	...do...	...do....	...do..	...do.....	.....

Each light keeper will be assigned a letter so chosen as not to be identical with or similar to any of the code letters. The stations which each light keeper is to occupy in succession are shown in the vertical column under his letter, while the horizontal lines show the location of the observer and the various light keepers at any time.

Thus when the observing party was at Haystack, light keeper "B" was at Rawhide, "D" at Hobbs, etc., and were showing their lights to Haystack; then the observer moved to Coleman, "B" moved to Haystack, and the other light keepers kept their stations, changing the pointing of their lights so as to show them to the observer at Coleman.

ELECTRIC SIGNAL LAMPS.

Before starting out alone be sure that you know how to use the lamp and connect up the batteries. Remember that batteries are very expensive and unless used with the utmost care they will deteriorate very rapidly and make the work expensive. The good judgment with which you use the lamp and batteries is a large factor in determining your value to the party when electric lamps are being used.

OUTFIT.

Your outfit for the electric lamp should include the following, exclusive of articles for the heliotrope and camping outfit:

Electric lamp in case, with screw driver, gimlet, sighting tube, reducing socket for flashlight bulbs, extra bulbs of the sizes needed, and screw for holding lamp to tripod head.

Battery connectors, sufficient to connect up 24 cells.

Twenty feet copper wire, No. 18, with waterproof insulation, to lead from cells to lamp. (Do not use longer lengths than necessary.)

Ammeter, pocket, for testing cells. This is different from the kind attached to the lamp board.

Dry cells. A full set consists of from 18 to 24.

Battery box, waterproofed by cover of tin or painted canvas.

Tarpaulin, about 10-ounce canvas, waterproofed by painting with boiled linseed oil.

THE LAMP.

As packed in its box, the lamp is in two main parts—the baseboard, which is to be fastened to the top of the

stand by the large nickeled screw, and the reflector in its hinged bracket. A brief description of the principal attachments follows:

Reflector.—The reflector is of frail construction compared to that of the carbide lamps and must be handled carefully to prevent rusting and scratching. Do not touch the reflector with the hands or polish it with anything except dry, soft chamois skin or clean tissue paper.

Sighting tube.—This tube has a sighting pin in the forward end and a notch in the middle of the semicircular wall, which half closes the eye end. The bracket which supports the rear end of the tube must be forced down into the socket at the back of the lamp as far as it will go and is so constructed that after the tube has been once adjusted for any certain bulb the tube can be taken out and replaced without disturbing the adjustment if the lock nuts on the two upper pins in the bracket are screwed down.

Focusing device.—This is the screw collar which surrounds the cord connectors which lead from the bulb contact to the brass slot connection in the baseboard. By turning the collar the bulb is moved in or out for focusing.

Rheostat.—The rheostat is of the usual coil form, with a slide contact, and is used only as a safety appliance to prevent burning out the bulbs when putting in new groups of cells. Increasing resistance is put into the circuit by moving the slide to the right, when facing the rear of the lamp. Further reference will be made to the

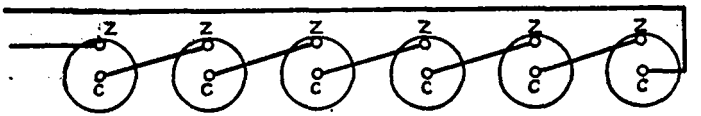
use of the rheostat after the battery connections have been described.

Ammeter.—This is used to measure the proper amount of current for the different sizes of bulbs, the amperage for which will be given later. In case the ammeter gets out of order so that the current will not pass through it, the wire can be disconnected from the binding post at the left-hand corner (when facing the rear of the lamp) and fastened to the small post at the left end of the rheostat, which will cut the ammeter out of the circuit.

BATTERY CONNECTIONS AND BULBS.

Taking for granted for the present that the lamp is properly pointed and focused, the brilliancy of the light will still depend upon four factors, namely, the number of batteries used, the method of connecting them, the kind of bulb used, and the amount of resistance in the circuit. Different methods of connecting the batteries will first be briefly considered.

Figure 1, on page 22, shows several batteries connected in series, the carbon pole of one battery being connected to the zinc pole of the next. When thus connected, the voltage increases each time a battery is added, and the total voltage is the sum of the voltages for the individual batteries. There is a proper voltage for each lamp bulb, for if the voltage is too low, a dim light is obtained, while if it is too high the bulb will be burned out.



z = zinc pole
c = carbon pole

FIGURE 1
Cells connected in series

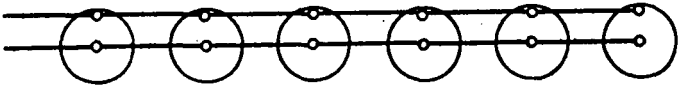


FIGURE 2
Cells connected in parallel

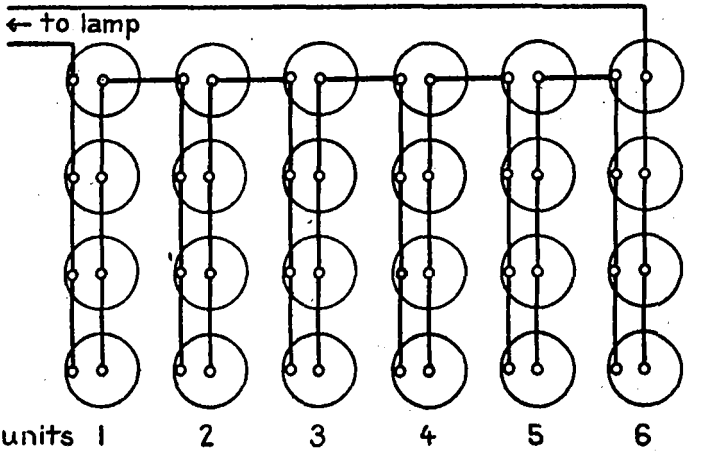


FIGURE 3
Series-parallel connection of 24 cells in 6 units of 4 cells each

Figure 2, on page 22, shows batteries connected in parallel, all the carbon poles being joined together and likewise the zinc poles. This method increases the amperage of the circuit, but the voltage is the same as that of a single cell. In other words, it is equal to a battery with the same voltage as the individual cell, but as many times as large as there are cells in the connection, thereby increasing the number of hours the lamp can be kept lighted.

Figure 3, on page 22, shows the series-parallel connection, which is the one used with the larger-sized bulbs and which should be thoroughly studied by the light keeper.

Large bulbs.—These are the large bulbs sent out by the Office and are specially made for these lamps, with a filament concentrated into as small an area as possible, so that the light may be concentrated by the reflecting lens into a horizontal beam of great intensity. They are rated by the manufacturers at 6 volts and 2 amperes for an average life of from 800 to 1,000 hours, but when the intensity of the light is the prime consideration the voltage should be increased to about 9 and the amperage to 2.4, but never above that amount. When the voltage is increased to that amount the life of the bulb should be about 40 hours, and will give as high as 250,000 beam candlepower.

The voltage of an ordinary battery, or of a unit of two or more batteries connected in parallel, is about 1½ volts, so that a voltage of 9 can be obtained by joining

in series six of these units. Figure 3 shows a combination frequently used for lighting the large bulbs, where there are 24 batteries so connected that there are 6 units connected in series, each unit consisting of 4 batteries in parallel. If weight is a serious consideration, the number of batteries in a unit may be reduced from four to three.

With fresh batteries 6 units of 4 cells each connected as above should burn well for about 20 hours, when the brilliancy will be reduced noticeably. Another unit should then be added, and still another as needed; when 8 units do not give the required amount of light, the older batteries should be thrown away and fresh units used.

Medium bulbs.—In case of an emergency, when the large bulbs furnished by the Office are not available, the commercial automobile-headlight bulbs, rated at 6 to 8 volts, may be used with the same combination of batteries as described for the large special bulbs, but they use almost as much current as the special bulbs and give a much less satisfactory light.

Flash-light bulbs.—These come in different sizes, but those rated at 3.8 volts are preferable. They will carry a slightly greater voltage, but rarely more than 4.5, and the ammeter should not show more than 0.25 ampere. Two units of fresh cells will be as much as the bulb will take, but as the batteries weaken it is possible to add the third, and even the fourth and fifth units, and get good results. Of course the batteries must be very

weak before the bulb would take four or five units. In using these bulbs the light keeper will have ample chance to alternate units, so as to rest those used on previous nights, which will greatly prolong the life of the cells. This bulb will give about 6,000 beam candle-power.

Use of rheostat.—When adding more units (thereby increasing the voltage) before connecting them up with the bulb be sure at all times to test them with pocket voltameter to be sure the voltage is not so great that it will burn out the bulb, or else push over the slide of the rheostat as far as it will go to the right before connecting the batteries, and then slowly remove the resistance of the rheostat while watching the ammeter on the lamp to see that the amperage is not being exceeded. Do not use the rheostat for the purpose of moderating the light, for it simply means that part of the current is being wasted in heating the rheostat, and the same effect can be secured by removing one unit of batteries from the circuit.

Focusing.—The lamp must be properly focused at all times, for no matter how brilliant the filament of the bulb may be, the light will not be effective at any distance unless well focused. Each bulb will be found to have a different focus, and this is true even of the same kind of bulbs, because the relative position of the filament to the bulb base is rarely the same. Therefore focus the lamp every time the bulb is changed, and refocus after the lamp has been shipped, for it is quite

likely that the vibration while traveling will cause a change. The focusing device has been described.

With the larger bulbs it is usually possible to focus them by pointing the light on a tree, tent, or dense bunch of brush, preferably about 50 meters distant, and turning the adjusting-screw collar until the center of the reflection is the brightest possible and the ring of outer light is at its smallest diameter. Remember it is not desired to have a large arc of light evenly distributed, but to have as much of it as possible concentrated to a surface the size of the lamp reflector and the center of that surface directed to the observer.

The flash-light bulbs are very difficult to focus, for the reason that there is rarely a sufficiently bright beam to see any distance away, and this is especially true on light nights. With these bulbs it is necessary to focus on objects close at hand, and sometimes it can be done in one's shadow if the moonlight is bright. A special effort should be made to focus them on the night previous to the one on which they will be needed, and the focus checked if the preliminary focusing was done under poor conditions.

Pointing the lamp.—The center of the most brilliant part of the beam must be pointed to the observer, and if the sighting tube is used in pointing its sights must be parallel to the light beam. To adjust the sights in the tube, point the lamp to some object near enough to outline the central bright beam and adjust the tube by

means of the two screws on the bracket, so that the sights point to a spot as far above the center of the beam as the sighting tube is above the center of the reflector, usually about 6 inches. When once adjusted the screws can be fastened in place by the lock nuts on them. The adjustment of the sighting tube must be checked each time the bulbs are changed. The pointing of the lamp itself may be roughly checked by sighting with the eye along the beam, both from directly above it and from the side. Mark the position of the lamp so it can be put back on the identical pointing if it should be moved off. Where the brightness of the lights permit, and when a man can be spared to do so, the observer will send out a *Z* to each light keeper each night so that the observer's location may be known exactly, but if a *Z* is not seen keep on showing as instructed, for the observer may be shorthanded at his station.

A light not properly pointed also causes errors in the work which can not be detected until all the stations of the triangle have been occupied, and thus may cause great delay and expense in the work.

Dead batteries.—Use the pocket ammeter to test the cells as they are used. Cells which show no energy should be thrown away, for if they are placed in circuit with other cells they cause more resistance to the current and tend to reduce all to an average voltage. Weak cells may be used with the flashlight bulbs, but all should be of about the same voltage. In general, cells of less than 4 or 5 amperes will be of no use.

MISCELLANEOUS NOTES.

1. Do not have long wires leading from the batteries to the lamp, as they only increase the resistance of the outer circuit.

2. Be careful that metal parts of batteries and connectors do not touch and that connectors are tightly fastened to batteries.

3. Watch that cells do not get wet; have slats nailed on the bottom of the battery box so that moisture will not be absorbed from the ground or platform.

4. Inform the chief of party of your need of batteries or bulbs far enough ahead that it will not cause undue expense or delay in supplying you.

5. Be sure that the wires from the batteries do not go to the wrong binding posts on the lamp. The wire from the zinc pole should go to the left-hand post on the lamp. If the wires are crossed the ammeter will not register.

6. To avoid any confusion in the connections, place all poles of the cells in a certain direction, as shown in figure 3. If cells with the Fahnstock clip are used, straight wires can be employed as connectors and the wiring simplified, but they are often not available except when ordering in large lots.

7. When shipping the lamp and batteries be sure that they are well packed and that the batteries can not become short circuited by loose pieces of metal or wires left in the box. All the nuts for the binding posts on the batteries should be screwed down tight, so that they will not be lost. Keep on hand a few extra nuts from dead batteries.

DOUBLE OBSERVING PARTY.

With two observing parties the work of the light keeper is a bit more complicated, since he must show lights to two stations at once and keep the moves of two observers in mind. The same signals will be used as with a single observing party, except that party No. 2 will send double *Z*'s instead of single ones, and will be spoken of in signaling as "*OO*" instead of "*O*." The light keepers must use their judgment in interpreting signals; for instance, if "*O*" sends *DG* 10 and the light keeper is being worked on by "*OO*" also, he will remain where he is until he receives a *DG* from "*OO*." The *DG* 10 simply means that "*O*" will be ready to work on the light keeper's new station on the tenth. In the above case the light keeper should signal, if possible, "*OO* not done," or something to that effect.

Since it is impossible to foresee the relative speeds of the two observing parties, it will be necessary at times to mark adjacent stations on the light keeper's schedule as "*a*" and "*b*"; in such cases it will be necessary for the light keeper to finish at the station marked "*a*" before going to "*b*," even though he knows the other observer is waiting for his light from "*b*."

When showing two lights, the problem arises of how to keep them both centered. There are two methods by which you can mount your second lamp. If a double-folding stand is furnished you, your second lamp will be mounted directly above the first in the place provided on the stand. Be sure in this case that the screw

fastening the upper lamp is plumbed directly over the hole in the tripod into which the double stand and the lower lamp are fastened. A box, with the bottom knocked out and the sides reinforced by strips, will answer in an emergency for the folding stand. Since the height of the helio and lamp must always be known, the light keeper must keep a record of which lamp, whether upper or lower, was pointed to the various stations on his schedule.

The second method is to mount the second lamp on a separate board or stand about the same height as the tripod and with the lamp *exactly* on the line from the hole in the top of the tripod to the station where the observer is. Unless the direction to the observer's station is known accurately and the lamp mounted with precision, this method leads to errors, so that the first method is preferable and more easily prepared.

If both observers are in almost the same direction from your station, take such precautions as you can, with partitions of some material between the beams from the two lamps, to insure that each observer sees only the light from the lamp directed to him, and none from the other lamp.

RELATING TO ACCOUNTS.

1. Receipts must always bear date and place.
2. Always give purpose of expenditures, unless plainly evident.
3. Receipts should be made in ink, if possible.

4. Make all explanations in writing on face of receipt.

5. Signatures by (X) are only to be made by persons unable to write their names. When made by (X), they must bear the name of the person and must be witnessed. (See sample general subreceipt 20.)

6. Do not lump items in receipts. They should be itemized.

7. Do not render receipts like this:

Matches, oil, and can..... 50c

but make it:

2 boxes matches, at 5c, 10c; 1 gal. oil, 15c; 1 oil can, 25c..... 50c

8. In hauling always give weight and distance, or number of days team was employed, dates, and rates per day.

9. In sending telegrams to chief of party, mark "Official Government Message" and send it "Collect," and at the same time send a duplicate copy of the telegram by mail. Messages connected with the work and not addressed to the chief of party should be marked "Official Government Business" and should be prepaid and a *duplicate* taken, with the agent's receipt on the face of the telegram. Government rates for telegrams vary from time to time; be sure to learn the current rates before taking the field. Everything is to be counted except the place and date. Make address, message, and signature as brief as possible, leaving off initials of persons' names.

10. Receipts for phone calls must show points between which call was made, number of minutes charged for, and how charge was computed, rate for overtime, etc.

11. Whenever an express bill is paid, take receipt from the agent for same and have indicated on the receipt seven things:

First. The receipt made out in your name.

Second. The place from which shipment was made.

Third. The place to which shipment was made.

Fourth. The weight of the shipment.

Fifth. The rate of the shipment per 100 pounds giving scale number by which classified. The last is very essential.

Sixth. The agent's signature in full, under the name of the express company, with the title of the person signing the receipt. The agent's signature by initials only is not sufficient.

Seventh. The method of packing, whether box, bundle, crate, or bale, and the contents of the shipment.

By omitting any of these, payment can not be made to you when the receipt is turned in. Be sure that the rate multiplied by the weight equals the charge, unless the weight is less than 100 pounds, when a graduated rate will apply. (See sample travel receipt No. 5.)

Railroad fares, freight, excess baggage, expressage, telegrams, and telephone messages are exempt from tax, but a certificate must be furnished the agent cover-

ing the tax. Railroad fares are covered by one form of certificate, transportation of property by another form, and telephone messages by a third form. See that you are supplied with each before taking the field. Telegrams are exempted by declaring them "Official business" when sending them. Telephone messages should be sent when possible from a central office, when no trouble will be experienced in securing exemption from tax, but when telephoning must be done from a subscriber station, arrangements can usually be made with central to leave with the subscriber an exemption certificate covering the tax.

A signed statement that "No war tax included in above charges" must be made below the items listed on the travel voucher.

12. Your accounts are to be rendered on or before the last day of each month and mailed to the chief of party with the least possible delay. The form of rendering accounts comes under two heads, namely, "Travel account" and "General account." They are to be kept distinctly separate. Sample forms of each are attached herewith, with the necessary explanatory notes. In sending accounts to the chief of party, state how many receipts are sent, the amount thereof, and make a statement showing the balance due you or the chief of party.

Receipts for supplies or services should not cover portions of two months. Receipts signed by an employee of

a firm, company, or corporation should be in the name thereof, and the full name and title, or occupation, of the person signing the receipt should be written below the name of the firm, company, or corporation, as:

Union Mercantile Co.,
Per John Smith,
Salesman.

13. You are requested to make a special effort to follow the above instructions in the smallest detail, for by so doing you will avoid a great deal of correspondence, get your money sooner, and greatly simplify the matter of accounts for the chief of party. Study these instructions carefully and READ THEM OVER FREQUENTLY. You have no chance of making your work satisfactory until you know how to put into practice each detail of these instructions.

TRAVEL ACCOUNT NOTES.

Receipts should be taken for all travel, except railroad fares.

Travel receipts should all be made out in your (heliotroper's) name.

For railroad fares, simply state the amount paid, between what points, over what railroad, and the distance between points.

By the word "travel" is meant railroad fares, express, excess baggage, team hire, horse hire, and, in fact, everything in the nature of traveling expenses.

Number your traveling receipts 1, 2, 3, 4, etc., according to dates, as shown in sample.

All expenditures for travel must appear on the travel voucher in the order of date, the travel voucher to be sworn to by the heliotroper individually. Any postmaster or the chief of party will administer the oath, and no charge can be made therefor. In case the oath is administered by a postmaster the space marked "L. S." on the voucher in the space for the affidavit should be stamped with the canceling stamp of that post office which shows the place at which oath was administered.

GENERAL ACCOUNT NOTES.

Besides the travel account, there is another one called "General account." This contains everything not included in the travel account, such purchases as oil, matches, nails, ax, oilcan, hire of man to assist in work, etc. GENERAL receipts are made out in the name of the chief of party. General receipts are left unnumbered.

[*Page 1 of sample travel voucher.*]

Department of Commerce
U. S. Coast and Geodetic Survey
Form 4

VOUCHER FOR REIMBURSEMENT OF TRAVELING EXPENSES.

(Form approved by the Comptroller of the Treasury October 5, 1907.)

Note General Instructions on back of voucher.

THE UNITED STATES,

To *Anderson, Jim*....., Dr.
(Name of payee.)

Address: *U. S. Coast and Geodetic Survey, Newcastle, Wyo.*
(Street and number.) (City or town.) (State.)

	DOLLARS.	CTS.
For REIMBURSEMENT of traveling expenses incurred in the discharge of official duty from *June 1* (*1st day of mo.*), 19*12*, to *June 30* (*last day of mo.*), 19*12*, under written authorization from the Superintendent, dated....., 19..—a copy of which is attached hereto and forms a part of this account—as per itemized statement herein set forth.		
AMOUNT CLAIMED.....	13	75

Affidavit and bill to be completely filled in by payee, or before signature by payee, without alteration or erasure at any time.)

OATH OR AFFIRMATION OF CLAIMANT.

I do solemnly* *swear* that the above account and schedule annexed are just and true in all respects, as verified by a memorandum kept by me; that the distances as charged have been actually and necessarily traveled on the dates therein specified; that the amounts as charged have been actually paid by me for traveling expenses; that I have not

and will not receive, directly or indirectly, from any person, agency, or corporation any sums as rebate on account of any expense of transportation included in this account; that none of such distances for which charge is made was traveled under any free pass on any conveyance; that no part of the account has been paid by the United States, but the full amount is justly due: that all expenditures included in said account other than my own personal traveling expenses were made under urgent or unforseen public necessity, and that it was not, for the reasons stated herein, feasible to have payment made for such expenditures by the Disbursing Agent of the Coast and Geodetic Survey. So HELP ME GOD.

(Signature) *Jim Anderson,*
(Official title) *Heliotroper, U. S. C. and G. Survey.*

L. S.

Subscribed and † *sworn* to before me at *Neccastle, Wyo.*, this *80* day of *June*, 19*12*.
John Doe, Postmaster.
My commission expires....., 19...

(Receipt to be signed only in case of payment in cash.)

Received of *C. V. Hodgson* in person, or by his deputy, and in cash, the sum of *Thirteen* dollars and *75* cents, in full payment of the above account, which I certify to be correct.

13\frac{75}{100}$ {NOT to be signed in duplicate.}

Jim Anderson.

I CERTIFY that the above account is correct and just; that the expenses were necessarily incurred, and I believe the same to have been paid as therein stated. Chargeable to appropriation—

"....."

and is approved for $ {Differences, if any, shown inside.}

.....

.....
(Official designation.)

Paid by *cash*, dated....., 19.., drawn on the Treasurer of the United States, to order of Payee named above for $.....

• Swear or affirm. † Sworn or affirmed.

[*Page 2 of sample travel voucher.*]

ITEMIZED STATEMENT of Traveling Expenses—and Other Expenses incurred under stress of urgent or unforeseen public necessity.

DATE.		CHARACTER OF EXPENDITURES.	SUB-VOUCHER NO.—	AMOUNT. DOLLS.	AMOUNT. CTS.
		Fill in form on this voucher showing how transportation requests were used.			
1912.					
June	*2*	*Hire of team and driver, 2 days at $3.50 per day*	*1*	*7*	*00*
"	*4*	*Excess baggage, Provo, S. Dak., to Newcastle, Wyo., 100 lbs. at $1.00*	*2*	*1*	*00*
"	*4*	*Express, Provo, S. Dak., to Newcastle, Wyo., 150 lbs. at $1.00*	*3*	*1*	*50*
"	*4*	*R. R. fare, Provo, S. Dak., to Newcastle, Wyo., about 49 miles*		*1*	*25*
"	*9*	*Stage fare, 20 miles, $1.00, freight 500 lbs. at 33 1/3 cents per cwt*	*4*	*2*	*00*
"	*10*	*Express, Provo, S. Dak., to Newcastle, Wyo., 75 lbs. at $1.00 per cwt. (Scale No. —)*	*5*	*1*	*00*
		No war tax included in the above charges. (Signature) *Jim Anderson.*			
		AMOUNT CARRIED FORWARD			

NOTE.—The date and hour of boarding and leaving trains MUST be stated in each instance.

[Sample—Travel.]

DEPARTMENT OF COMMERCE AND LABOR
COAST AND GEODETIC SURVEY
Form 5 MEMORANDUM SUBRECEIPT.
(Form approved by the Comptroller of the Treasury October 31, 1908)

$7.00 No. 1 *Provo, S. Dak., June 2, 1913.*

RECEIVED OF - - - - - - - - - - *Jim Anderson,* - - - - - - - - - - in person, and IN CASH,

the sum of - - - - - - *Seven* - - - - - - Dollars and - - - - - - *No* - - - - - - - - - - Cents,

for *hire of team and driver for two days, June 1 and 2, at $5.50 per day.*

(*The receipt should not be dated earlier than the last day for which charges are made.*)

*Witness: ..... (*To be signed here by man furnishing the team.*)

* Only signatures by mark (×) need be witnessed.

[Sample—Travel.]

DEPARTMENT OF COMMERCE AND LABOR
COAST AND GEODETIC SURVEY
Form 5 MEMORANDUM SUBRECEIPT.
(Form approved by the Comptroller of the Treasury October 31, 1908)

$1.00 No. 2 *Newcastle, Wyo., June 4, 1912.*

RECEIVED OF - - - - - - - - - - *Jim Anderson,* - - - - - - - - - - in person, and IN CASH,

the sum of - - - - - - - *One* - - - - - - Dollars and - - - - - - *No* - - - - - - - Cents,

for *excess on 100 lbs. baggage, Provo, S. Dak., to Newcastle, Wyo., at $1 per hundred.*

.....

* Witness: ..... *(To be signed here by baggage agent.)*

* Only signatures by mark (X) need be witnessed.

[Sample—Travel.]

DEPARTMENT OF COMMERCE AND LABOR
COAST AND GEODETIC SURVEY
Form 5 MEMORANDUM SUBRECEIPT.
(Form approved by the Comptroller of the Treasury October 31, 1908)

$1.50 No. *5* *Newcastle, Wyo., June 4, 1912.*

RECEIVED OF - - - - - - - - - *Jim Anderson,* - - - - - - - - - - in person, and IN CASH, the sum of - - - - - - *One* - - - - - Dollars and - - - - - - *Fifty* - - - - - - - Cents, for *express on outfit, Provo, S. Dak., to Newcastle, Wyo., 150 lbs., at $1 per hundred, packed in three boxes and two bundles.* (*Scale No.* .....)

(*The agent's receipt is just as good as the above, or even preferable, if all the necessary information is shown thereon.*)

* Witness: ..... (*To be signed here by express agent.*)

* Only signatures by mark (×) need be witnessed.

[Sample—Travel.]

DEPARTMENT OF COMMERCE AND LABOR
COAST AND GEODETIC SURVEY
Form 5
(Form approved by the Comptroller of the Treasury October 31, 1908)

MEMORANDUM SUBRECEIPT.

$2.00 No. 4 *Newcastle, Wyo., June 9, 1912.*

RECEIVED OF - - - - - - - - - *Jim Anderson*, - - - - - - - - - - in person, and IN CASH the sum of - - - - - - *Two* - - - - - - - Dollars and - - - - - - *No* - - - - - - Cents,

for *stage fare for himself, for 20 miles,* $1.00
freight on 100 lbs. of baggage at 33⅓c. per cwt. 1.00
Total, $2.00

.....

*Witness:..... (To be signed here by stage-driver.)

*Only signatures by mark (X) need be witnessed.

[Sample—Travel.]

DEPARTMENT OF COMMERCE AND LABOR
COAST AND GEODETIC SURVEY
Form 5
(Form approved by the Comptroller of the Treasury October 31, 1908)

MEMORANDUM SUBRECEIPT.

$1.00 No. *5* *Newcastle, Wyo., June 10, 1912.*

RECEIVED OF - - - - - - - - - *Jim Anderson,* - - - - - - - - - in person, and IN CASH, the sum of - - - - - - *One* - - - - - - - Dollars and - - - - - - - *No* - - - - Cents, for *expressage on 1 box carbide from Provo, S. Dak., to Newcastle, Wyo., 70 lbs. at $1.00 per hundred=$1.00, graduated rate, Scale No.* .....

(*The information shown on this receipt may be written across the face of the regular express receipt.*)

.....:

*Witness:.....

(*To be signed here by express agent.*)

*Only signatures by mark (×) need be witnessed.

[Sample—General] (20)

DEPARTMENT OF COMMERCE AND LABOR
COAST AND GEODETIC SURVEY
Form 5
(Form approved by the Comptroller of the Treasury October 31, 1908.)

MEMORANDUM SUBRECEIPT.

$4.00 No. ..... *Newcastle, Wyo., June 19, 1912.*

Received of - - - - - - - - - - *C. V. Hodgson,* - - - - - - - - - - - - in person, and IN CASH,

the sum of - - - - - - *Four* - - - - - Dollars and - - - - - - *No* - - - - - - - - Cents,

for *labor for two days, June 18 and 19, at $2 per day*

*WITNESS: *Signature of witness.*

His
Pete X Crow
mark

*Only signatures by mark (X) need be witnessed.

[Sample—General] (21)

DEPARTMENT OF COMMERCE AND LABOR
COAST AND GEODETIC SURVEY
Form 5 MEMORANDUM SUBRECEIPT.
(Form approved by the Comptroller of the Treasury October 31, 1908.)

$1.55 No. ..... *Provo, S. Dak., June 1, 1918.*

Received of - - - - - - - - - - *C. V. Hodgson,* - - - - - - - - - - in person, and IN CASH the sum of - - - - - - *One* - - - - - - Dollars and - - - - - - *Thirty-five* - - - - - Cents, for

5 lbs. nails at 5c	=*$0.25*
1 axe	=*1.00*
2 boxes matches at 5c	=*0.10*
Total	=*$1.55*

WITNESS: .....

(*To be signed here by salesman.*)

*Only signatures by mark (X) need by witnessed.

[Sample.]

TRANSMITTING LETTER OF MONTHLY ACCOUNTS.

NEWCASTLE, WYO., *June 30, 1912.*

Mr. C. V. HODGSON,
Chief of Party, C. & G. Survey.

SIR: Enclosed please find two general receipts aggregating $5.35
Also find enclosed my June travel voucher 13.75

Total 19.10

Amount due chief of party June 1 ..... 3.15
Advances by chief of party during June 20.00

Total advances 23.15
Expenditures as above 19.10

Balance due chief of party June 30 ..... 4.05

Respectfully,

(Sign here) .....

Heliotroper.

ACTIVITIES OF THE U. S. COAST AND GEODETIC SURVEY.

The work of the Survey embraces a great many other operations besides primary triangulation, and for the general information of the light keeper and to help him to answer some of the innumerable questions which are always asked him regarding the Survey and its work, some of its principal functions are briefly mentioned below. Those who desire a more detailed account will find it in Special Publication No. 23, "The Work of the Coast and Geodetic Survey," which can be obtained free of charge by application to the Superintendent, U. S. Coast and Geodetic Survey, Washington, D. C.

To all nations whose territories touch the sea or who have any interests in the commerce of the sea a full and complete knowledge of the coast, its nature and form, the character of the sea bottom near it, the location of reefs, shoals, and other dangers to navigation, the rise and fall of the tides, the direction and strength of the currents, and the character and amount of magnetic disturbance, is of the greatest practical value.

To supply this knowledge the Governments of the principal maritime nations have in modern times made surveys of their coasts by the most exact methods, and it was for this purpose that the U. S. Coast Survey was organized more than a hundred years ago. In 1871 the scope of the Survey's work was enlarged to include the determination of geographic positions and other data for the surveys of the interior states, and in 1878

its designation was changed to "The Coast and Geodetic Survey." The word "geodetic" refers to the various operations and investigations in which the curvature of the earth's surface is taken into account, instead of treating the surface as a plane as is the case in ordinary surveying.

To-day the work of charting the hundred thousand miles of detailed shore line and adjacent waters of the United States and its possessions is being carried on by the 10 or 12 steamers operated by the Survey and by various launch and shore parties. The depths of water and the character of the bottom are ascertained by the lead line, either hand lead or sounding machine. In depths up to 20 fathoms the hand lead is used. This consists simply of a piece of lead, somewhat in the shape of a window weight, attached to a marked cord, and is thrown by a leadsman from a sounding platform in the bow of the boat. With a sounding machine the lead is attached to a wire wound upon a reel, which may be either hand or steam operated, the wire also passing over a device which registers on a dial the length of wire which has run out. In very deep water the lead is detachable and after a sounding the wire only is reeled in, together with an attachment for bringing up a specimen of the bottom. The depths of water so determined are afterwards shown on a nautical chart in their proper relation to the shore line and to the parallels and meridians marked on the chart, with lighthouses, buoys, and all topographic features which may aid the mariner, indicated by symbols in their proper location.

In regions where submerged ledges and pinnacle rocks occur frequently in the waters traversed by ships, the lead line will not always disclose these dangers. Before it can be said with certainty that a given region is safe for shipping, it must be examined with a wire drag. This is a wire suspended horizontally in the water at any desired depth by means of vertical wires leading up to buoys at the surface. This drag may vary in length from a few hundred feet to more than 4 miles, and is towed through the water by launches so as to sweep the area to be examined at the depth at which the horizontal wire is set. Whenever an obstruction projects above that depth, whether it be a rock, sand bar, or submerged wreck, the horizontal wire catches upon it or is lifted by it and the location of the danger is indicated by the buoys from which the horizontal wire is suspended.

As a basis for the determination of geographic positions to be furnished to State surveys, and to serve in the accurate location of national, State, and county boundaries, and as a foundation for other Government surveys and for map makers and surveyors, the latitude and longitude of a network of points over the entire country must be determined, together with the distances and directions between them. (A more detailed account of the purposes and methods of primary triangulation is given in the introduction to this pamphlet.) This the Coast and Geodetic Survey does by extending its primary triangulation into all parts of the

country as rapidly as facilities are provided. Connected with this are other geodetic operations, such as star observations for latitude, longitude, and azimuth, and the swinging of pendulums to measure the force of gravity. The Survey has several fixed observatories where measurements are made of the variation of latitude at a given place, which is caused by a slight wabbling of the earth as it rotates on its axis.

But the engineer or surveyor is not content to know simply the latitude and longitude of a place; he needs to know its elevation above sea level as well. The precise leveling of the Coast and Geodetic Survey extends along many of the principal railway lines of the country and the bench marks established serve as a basis for any further leveling done in their respective localities.

Both the navigator at sea and the surveyor ashore need to know the magnetic declination or the amount the compass north varies from the true north. For instance, in the northeastern part of Maine the magnetic needle points 22 degrees west of north, while in the northwestern part of the State of Washington it points 25 degrees east of north, a difference of 47 degrees within the limits of the United States. Moreover, the angle between the compass and the true meridian is constantly changing. Even in the course of a day, from 8 in the morning until 2 in the afternoon, the needle changes its direction by an amount sufficient to be taken into account. This change may cause a discrepancy at the terminus of a line a mile long, run by the compass

in the morning and rerun in the afternoon, amounting to from 5 to 20 feet, according to the season of the year. To determine the amount and rate of the error of the compass, as well as the inclination and intensity of the magnetic force, a great number of observations are made annually by the Survey, either at fixed observatories in the United States, Porto Rico, Alaska, and Hawaii, or by special parties sent out to different parts of the country. Sometimes the various field parties of the Survey on sea and on shore make magnetic observations as an adjunct to their regular surveying work.

The principal publications of the Survey consist of 645 different charts, covering all the coasts of the United States and its outlying insular possessions: annual tide tables for all the principal and many of the minor ports of the world, the most comprehensive volumes of this class issued by any country; Coast Pilots, containing sailing directions for all navigable waters along our coast; special publications which give, in a form suitable for use by surveyors and engineers, the geographic positions and descriptions of triangulation stations, the elevations and descriptions of precise leveling bench marks, and data for the magnetic stations: the annual report of the Superintendent on the conduct of the work; and special reports upon the various technical and scientific operations of the service.